

CLAIMS

[1] A contaminated solid material clarification method for removing heavy metals from a contaminated solid

5 material containing the heavy metals, comprising:

performing a dissolution step and a separation step in parallel in an identical container, the dissolution step being a step of dissolving heavy metal ions from the solid contaminated material, and the separation step being a step
10 of separating the dissolved heavy metal ions from the contaminated solid material and interstitial water; and

maintaining the contaminated solid material in a condition of a reducing atmosphere and a strongly acidic or strongly alkaline atmosphere until dissolution and
15 separation of the heavy metal ions are completed.

[2] The method according to claim 1, characterized in that the reducing atmosphere is provided by rendering a cathode potential -0.16V or lower with respect to a hydrogen standard electrode potential.

20 [3] The method according to claim 1, characterized in that the reducing atmosphere is provided by rendering a cathode potential -0.25V or lower with respect to a hydrogen standard electrode potential.

[4] The method according to claim 1, characterized in
25 that the reducing atmosphere is provided by controlling a current density from a cathode to an anode within a range of 0.01 to 10A/L of a reaction liquid.

[5] The method according to any one of claims 1 to 4,

wherein the strongly acidic atmosphere is such that a pH of the interstitial water of the contaminated solid material is 3 or lower, and the strongly alkaline atmosphere is such that the pH of the interstitial water of the contaminated
5 solid material is 12 or higher.

[6] The contaminated solid material clarification method according to any one of claims 1 to 5, characterized in that the step of separating the heavy metal ions includes a step of depositing the heavy metals on a cathode surface,
10 and during the deposition step, the heavy metals are deposited on the cathode surface under conditions, under which a flow of a slurry containing at least the contaminated solid material is controlled or suppressed so as to decrease a shearing force of the slurry acting on the
15 cathode surface so that the shearing force acting on the cathode surface does not impede deposition of the heavy metals.

[7] The method according to claim 6, characterized in that decrease of the shearing force is performed by
20 positioning a cathode upwardly in the slurry, and controlling a solid particle size distribution in the slurry such that solids of small particle diameters in the slurry are present at an upper position in the slurry, and solids of large particle diameters in the slurry are
25 present at a lower position in the slurry.

[8] The method according to claim 7, characterized in that the solid particle size distribution in the slurry is controlled by imparting an upward flow of the slurry at a

controlled flow velocity.

[9] The contaminated solid material clarification method according to any one of claims 1 to 8, characterized in that plural cathodes are arranged in the reaction vessel, and the dissolution step and the separation step are performed in parallel in the reaction vessel.

[10] The contaminated solid material clarification method according to claim 9, characterized in that at least one of the plural cathodes is a cathode for dissolution mainly acting to dissolve the heavy metal ions, and at least one of the other cathodes is a cathode for deposition mainly acting to deposit the heavy metal ions.

[11] The contaminated solid material clarification method according to claim 10, characterized in that the cathode for deposition is located at a position near to an anode than the cathode for dissolution.

[12] The contaminated solid material clarification method according to claim 10 or 11, characterized in that the cathode for deposition and the cathode for dissolution are controlled to electrode potentials different from each other.

[13] The contaminated solid material clarification method according to any one of claims 10 to 12, characterized in that the cathode for deposition and the cathode for dissolution comprise substances having standard electrode potentials different from each other, and the substance having a relatively high standard electrode potential is used as the cathode for deposition, while the substance

having a relatively low standard electrode potential is used as the cathode for dissolution.

[14] The contaminated solid material clarification method according to any one of claims 10 to 13, characterized in
5 that the cathode for deposition is composed of a substance on which the deposited heavy metals are electrodeposited more easily than a substance constituting the cathode for dissolution.

[15] A contaminated solid material clarification
10 apparatus including a reaction vessel comprising contaminated solid material supply means for supplying a contaminated solid material containing heavy metals, a cathode for providing a reducing atmosphere, a diaphragm, and an anode, and wherein

15 the diaphragm defines an anode zone containing the anode, and a cathode zone containing the cathode and the contaminated solid material supply means, and

the cathode zone is maintained in the reducing atmosphere and a strongly acidic or strongly alkaline
20 atmosphere, and dissolution of heavy metal ions from the solid contaminated material, and separation of the dissolved heavy metal ions from the contaminated solid material and interstitial water are performed in parallel in the reaction vessel.

25 [16] The contaminated solid material clarification apparatus according to claim 15, characterized in that the cathode zone of the reaction vessel is further provided with acidic substance or alkaline substance supply means

for supplying an acidic substance or an alkaline substance.

[17] The contaminated solid material clarification apparatus according to claim 15 or 16, characterized in that the reaction vessel is further provided with shearing
5 force suppressing means to decrease a shearing force exerted on a surface of the cathode by a slurry containing at least the contaminated solid material supplied to the reaction vessel, and also maintain a state of contact between the cathode and the slurry.

10 [18] The contaminated solid material clarification apparatus according to claim 17, characterized in that the shearing force suppressing means is slurry upward flow providing means for giving the slurry as an upward flow at a predetermined flow velocity.

15 [19] The contaminated solid material clarification apparatus according to claim 18, characterized in that the slurry upward flow providing means includes a slurry withdrawal port provided in an upper portion in an interior of the reaction vessel, a slurry introduction port provided
20 at a bottom of the reaction vessel, and a circulating pump for circulating the slurry from the slurry withdrawal port to the slurry introduction port, and is arranged to raise the slurry from the bottom of the reaction vessel in the reaction vessel at a desired speed.

25 [20] The contaminated solid material clarification apparatus according to claim 17, characterized in that the shearing force suppressing means is a flow controlling mechanism for controlling a flow of the slurry so as to

reduce the shearing force of the slurry flow exerted on the cathode surface, and is a flow controlling member composed of one or more materials selected from a plate material, a porous material, a honeycomb-shaped material, and a
5 network-shaped material.

[21] The contaminated solid material clarification apparatus according to any one of claims 15 to 20, characterized in that plural cathodes are arranged in the reaction vessel.

10 [22] The contaminated solid material clarification apparatus according to claim 21, characterized in that at least one of the plural cathodes is a cathode for dissolution mainly acting to dissolve the heavy metal ions, and at least one of the other cathodes is a cathode for
15 deposition mainly acting to deposit the heavy metal ions.

[23] The contaminated solid material clarification apparatus according to claim 22, characterized in that the cathode for deposition is located at a position near to an anode than the cathode for dissolution.

20 [24] The contaminated solid material clarification apparatus according to claim 22 or 23, characterized in that the cathode for deposition and the cathode for dissolution are controlled to electrode potentials different from each other.

25 [25] The contaminated solid material clarification apparatus according to any one of claims 22 to 24, characterized in that the cathode for deposition and the cathode for dissolution comprise substances having standard

electrode potentials different from each other, and the substance having a relatively high standard electrode potential is used as the cathode for deposition, while the substance having a relatively low standard electrode potential is used as the cathode for dissolution.

[26] The contaminated solid material clarification apparatus according to any one of claims 22 to 25, characterized in that the cathode for deposition is composed of a substance on which the deposited heavy metals are electrodeposited more easily than a substance constituting the cathode for dissolution.

[27] The contaminated solid material clarification apparatus according to any one of claims 15 to 26, characterized in that the diaphragm is positioned so as to surround the anode, thereby forming the anode zone inwardly of the diaphragm and forming the cathode zone outwardly of the diaphragm.

[28] The contaminated solid material clarification apparatus according to claim 27, characterized in that the diaphragm is unitized in a cylindrical, box-shaped or bag-shaped form composed of the diaphragm alone or a combination of the diaphragm and other reinforcement, and the anode is positioned within the unit.

[29] The contaminated solid material clarification apparatus according to claim 27 or 28, characterized in that the cathodes are arranged in a stellate or radial configuration so as to surround the diaphragm.

[30] A clarification apparatus for a contaminated liquid

material containing heavy metals, comprising a reaction vessel including a cathode for providing a reducing atmosphere, a diaphragm, and an anode, and wherein

the diaphragm is positioned so as to surround the anode, thereby forming an anode zone inwardly of the diaphragm and forming a cathode zone outwardly of the diaphragm.

[31] The clarification apparatus according to claim 30, characterized in that acid or alkali supply means for supplying an acid or an alkali to the reaction vessel is further provided.

[32] The clarification apparatus according to claim 30 or 31, characterized in that the diaphragm is unitized in a cylindrical, box-shaped or bag-shaped form composed of the diaphragm alone or a combination of the diaphragm and other reinforcement, and the anode is positioned within the unit.

[33] The clarification apparatus according to any one of claims 30 to 32, characterized in that the cathodes are arranged in a stellate or radial configuration so as to surround the diaphragm.